DOCUMENT RESUME

ED 297 712 IR 013 416

AUTHOR Shannon, A. G.; And Others
TITLE Collection of Articles on Computers and Information Technology.
PUB DATE 84
NOTE 29p.; Portions contain light/marginally legible type.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Collected Works - General (020)

EDRS PRICE MF01/PC02 Plus Postage
DESCRIPTORS Artificial Intelligence; Communications; *Computer Assisted Instruction; *Computer Literacy; *Computers; Computer Uses in Education; *Curriculum; Information Processing; *Information Technology
IDENTIFIERS *Intelligent CAI Systems

ABSTRACT

Four articles focus on computers, information technology, and education: (1) "Information Technology: Some Implications for Education" (A. G. Shannon, B. S. Thorton, and Gareth Locksley) examines the last phase of technological development, the communication phase, as it relates to computer technology in education; (2) "Computers in the Curriculum" (A. G. Shannon) examines the integration of computers into the school curriculum in light of the development of information processing technology; (3) "Intelligent Computer-Aided Instruction" (A. G. Shannon) discusses some controversial issues in artificial intelligence as signs of confusion about computers, and suggests that there is a philosophical basis for this confusion; and (4) "Computer Technology and the Curriculum: Some Questions" (A. G. Shannon) raises some concerns about the rapid inclusion of computer technology in the world of education, and questions some of the assumptions underlying the educational use of computers and their possible effects on the curriculum. References are provided in each article. (EW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED297712

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

Minor changes have been made to improve reproduction quality.

Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

COLLECTION OF ARTICLES ON COMPUTERS AND INFORMATION TECHNOLOGY

by

A.G. Shannon

1983-1986

IR013416

BEST COPY AVAILABLE

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

A.G. Shannon

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

New Education, Vol. 5 No. 1, 1983

INFORMATION TECHNOLOGY: SOME IMPLICATIONS FOR EDUCATION

A. G. SHANNON & B. S. THORNTON

The School of Mathematical Sciences
The New South Wales Institute of Technology

GARETH LOCKSLEY

School of the Social Sciences and Business Studies
The Polytechnic of Central London

INTRODUCTION

The "micro" revolution of the seventies has caused a reappraisal of the role and significance of the computer in education. The reductions in costs have altered the cost-effectiveness perspectives. The increases in power have made practicable what was previously merely feasible.

In a previous article (Shannon and Thornton, 1982) consideration was given to computers in relation to instruction in general, to work and to energy. It is the purpose of this paper to consider aspects of computer technology's communication phase in relation to education.

The historical development of technology in general has been through three stages: production, distribution and communication. Examples of each since the industrial revolution include motorised mills, foundries, factories (production), motorised ships, trains, aeroplanes (distribution), and telephones, telex, satellites (communication).

In fact, any technological development goes through these phases, and computer technology is no exception. It is on the third of these stages, communication, that we wish to concentrate. The connection is important in so far as education involves a communication exchange between student and teacher, and because of the changing world of work in which our students will find themselves.

COMPUTER TECHNOLOGY AND EDUCATION

In any discussion of educational futures the implications of computer technology loom large. The concern of educators is well founded when one considers the generally poor response by educators to other technological advances.

Not that educators differ in this respect from society in general. "The advent of modern technology should have meant that we have a society in which everyone owns sufficient wealth to satisfy his material needs, and has sufficient leisure for recreation and the development of his higher, more human powers. But do we? Technology can produce an abundance of wealth, but curiously many men have to work overtime and their wives have to work to keep pace with the products of technology. True, many of the objects which the advertising world makes us believe are essential would have been luxuries for our parents, and some indeed are luxuries in any era. But to over-emphasise this is to overlook the realities of social life and to under-estimate the existence of poverty as manifest in the modern poor laws, or as they are called, social

BEST COPY AVAILABLE

services" (Singh and Shannon, 1980).

By reacting against the new technologies or by adopting them uncritically, it is very difficult to come to terms with their strengths and limitations. In order to make effective use of computer technology within education it is appropriate to distinguish amongst teaching (or learning)

(a) computing
(b) by computers
(c) with computers
(d) about computers.

The computer can also be used as an educator's tool in

(e) curriculum support applications
(f) administration applications
(g) communication applications.

Too often time and money are wasted in acquiring unsuitable hardware because these distinctions are not understood. Furthermore, just because some things can be done with the aid of computers does not mean that they should be done.

The implications of this for the professional educator in considering computing innovations include such questions as how do they relate to the aims of education, the aims of the school, the aims of this lesson. Thus, some of the advantages of computer assisted instruction can include: focussing student attention; bringing experiences into the classroom which are otherwise unattainable; preserving "once-off" events and experts; making learning experiences more concrete; adding effective impact to education; visualising theoretical or unobservable processes; giving instruction uniform quality; providing efficient storage and retrieval of information; providing simulated experience and realistic practice; individualising instruction (Ausburn and Ausburn, 1980). There are, in fact, many more and the interested reader can obtain from one of the authors a relevant report on the topic (Shannon and Ozanne, 1982).

INFORMATION TECHNOLOGY

King (1980) distinguishes two aspects of technology: one is based on practical experience and the other on theoretical knowledge. Roemer's (1980) reflection on the latter leads to a statement of the purpose of technology as control of anything that is part of the human environment.

The appropriateness of computer technology, in the broadest sense of the term, depends on a wider perspective, however, if we are not to confuse means and ends. It is in this context that we raise issues for consideration on computer technology and communications, focussing on the practical concerns of education in the provision of social and life skills, and the provision of vocational and marketable skills.

The convergence of telecommunications and computer technology into information technology (IT), or telematique, fundamentally changes the nature of the above skills. Education, as a medium for the transmission of information, is a form of communication. IT makes further demands on educators though: educators will be required to respond to the needs of a society where information, the ability to handle information and its associated "hardware" and "software", and the power of information with its economic effects on productivity and leisure, will intrude more and more into the lives of all of us.

We do not wish to get involved with futurology but there is a general concensus that in an industrial and wealthy society IT will have a major impact on

(a) work — content, nature, skills, number employed, working life, leisure time and unemployment;
(b) the technological environment or information society — ways in which we transact and acquire

information (and more information), that is, how we communicate.

The impact of IT on work implies a change in the requirement in marketable skills and social skills and the relationship between leisure and unemployment. The impact of IT on the technological environment implies a change in the necessary social skills that individuals will need in order to use IT equipment, which will have to be made generally usable, that is, with "user friendly" software.

A fundamental consequence of IT on skill is that it tends to remove a middle layer of skills: skill requirements are polarised at the top and bottom. At the top there is both an increase in the skill required and a change in the nature of the skills: enhancement plus alteration. At the bottom the mundane tasks will remain. This raises the question of the number of available jobs and job sharing. This involves industrial relations on the one hand but an important consequence of IT for education is the need to provide new leisure skills.

More and more of our students will not only encounter IT in their daily lives, in transport, in shopping, in their homes, but an increasing proportion of the work force will be employed in IT. Even in 1970 in the U.S.A. some 40% of the workforce could be considered to have employment in the "information sector"; similar developments are likely to occur in Australia. This links with the four categories of computer technology and education listed in an earlier section. Teaching by, with and about computers relates not only to work *per se* but also to social skills, whilst teaching computing will of itself gain much greater importance in the management of IT and making IT usable for both information workers and the social skills of everyone.

It is in this sense that Bellini emphasises the "knowledge is power" chasm of a future Britain with a social system divided into two distinct parts.

"There will be the tiny fraction that is modernised, with its optical fibre conduits, its word processors and its mini-computers, its facsimile machines and its teletext. The workforce of this sector will be educated and skilled in the arts of *compunications* — the buzzword of the C3 society. They will converse in a version of Orwell's Newspeak, a language he himself had imagined for the later years of the society of 1984 but which seems to have arrived already in the computer programmes of the information industry: 'byte-parallel I/O', 'hexadecimal', 'ultra-violet erasable PROM', 'scratchpad RAM' are just a taste of the vocabulary of the closed world of communications. This closed world will have its own monastic orders of specialists, steeped in the rituals of the computer. They will guard the secrets of their work jealously: millions in company profits will hinge on the control of key data about markets, products or corporate plans for the future. They will shelter behind the protective walls of corporate security, and the vital computer store will be defended by the sophisticated weapons of electronic warfare: voice recognition devices to supervise passwords, decoding apparatus to prevent access to sensitive files by unwanted intruders, heat sensors to detect the presence of unauthorised personnel. They will in every sense reproduce the siege conditions of those troubled times all those centuries ago."

"Outside the city walls there will be the other, forgotten side of the divided economy of the 1990s. The mass of unemployed, under-employed and the de-skilled will, by then, have fallen prey to the accelerating collapse of British industry. They will be the men and women who cannot find haven inside the domain of the information industry, because they lack specialised training or privileged access to the small job market offered by the compunications sector. This mass of unwanted labour will come to regard the information economy as a closed world to which they cannot be admitted" (Bellini, 1981).

By way of a specific example of the impact of computer technology on one section of the communications industry we consider aspects of the automation plan for a particular group of newspapers.

We do this, not because the technical details are relevant to our argument, but to underline the extent of the industrial revolution now taking place. (The extracts are from Thornton and Stanley, 1978.)

GRAPHIC ARTS AND COMPUTER TECHNOLOGY

In 1440, Johannes Gutenberg, a German printer, invented movable type, probably the greatest invention since the wheel. This single invention was the beginning of the printing industry which has done more than any other to teach and to record. Hand type was used for over 400 years until the invention of the Linotype in 1886 by Ottmar Mergenthaler. The first Linotypes began arriving in Australia in the 1890s. Compositors learned the keyboard and set type in lines instead of hand type letter by letter. This method continued almost unchanged until the early 1960s when computers entered the printing industry.

What the computer did in the 1960s was justify, or space out evenly, each line of type from text punched onto a paper tape by a perforator (TTS) operator. It effectively took over the end-of-line decision, leaving the operator free to concentrate on keyboarding text, and increasing his setting speed from 6-8 lines a minute to about 10. (Fully computerised typesetters can now set type at more than 3,000 lines a minute.)

Linotype manufacture ceased in North America several years ago. It has almost ceased in England and Europe. Here, in Australia now, there is no market for the machines. Disused models finish up being sold for scrap metal or museum pieces. The Linotype, which caused a revolution in his day, is on the way out.

By 1975, Fairfax newspapers were already partly automated but, it was necessary to make further changes. The profitability of newspapers had declined remarkably. Consequently, management had to look at every opportunity of increasing efficiency and eliminating waste, whether it was wasted material, like paper, or unnecessary human effort.

A similar situation overseas had forced a remarkable series of developments in the technical area, which newspapers everywhere hailed as offering a solution to the problem of rising costs and falling revenues. These technical developments mostly depended on computers.

One of the first pieces of equipment introduced in this area was the scanner. It had a reading head which scanned typewritten text, line by line, at up to 1200 words a minute and converted it into type. It was followed soon after by the video display terminal. This allowed reporters to write stories and sub-editors to edit them on the VDT screen, then transmit them directly into a data base and onto computer-driver typesetters. Other VDTs allowed sub-editors to retrieve text from computer storage, display the stories on a page and dispatch the made-up page, heads and all, to a typesetter. There were also computer systems designed to accept and store tens of thousands of classified ads, sort them into correct classifications and into alphabetical order and pass them out to a typesetter in single column form.

Most of these devices could be bought virtually off the shelf. They arrived at an appropriate time because they offered an opportunity for newspapers to break out of the stranglehold of falling revenues and rising costs. Furthermore, the old technology was simply going to disappear. Hot metal typesetting had reached the end of its technological development with linecasters operated by paper tape. This produced type at the rate of 9-10 lines a minute — there was just no faster way of producing metal type. Another disadvantage was that hot metal technology meant everything had to be re-keyboarded in the composing department after it had already been keyboarded by the person who created the item, either as a story or as an ad. This was wasteful duplication, and introduced re-keyboarding errors which had to be detected and corrected. Also, metal type was heavy and cumbersome. In American newspapers, hot metal began to disappear ten years ago. The rate of its disappearance accelerated through the '70s until now more than 90 percent of US newspapers have eliminated it from their operations.

Fairfax's automation program really started to take form in 1975. That was when the company contracted with a Dutch software group, Arsycom, to design a system for its five Sydney-based newspapers. The specifications were complex and extensive. As well as covering the various requirements of five newspapers, the system had to process one of the world's biggest classified ad volumes — about 1,000 columns or more than 20,000 ads on a single night.

Stage One of the project was the introduction of the display advertising layout system known as the Harris 2200 System. A 2200 System consists of a small computer and three or four video display terminals. It allows an operator with lay-out ability to call the text of an ad out of the computer on to his VDT screen and give it the best display within the space for it. By using various command keys on the terminal's keyboard he can specify type sizes and make single words or whole sentences larger or smaller. He can change the spacing between words and between lines. He can keep enlarging the type until it will no longer fit the space allowed, in which case the characters on the screen begin flashing to warn him the line is too long.

The text which he is to lay out will have been keyboarded elsewhere by somebody using another type of VDT. It will have been entered into the computer system as plain run-on text, all in one size, and will appear on the Harris 2200 VDT screen in this form. It is his job to display it to its best advantage. When he is satisfied with what he has done, he taps a key to transmit the ad to a computer store where it stays until required for typesetting. The overall Fairfax System includes two Harris 2200 systems at present, with provision for more to be added in the future.

StageTwo — the classified Ads System — is the biggest and most complex of the whole project. Initially it involves 160 VDTs. Classified ads 'phoned in by clients are typed "on screen" and entered directly into the system. The accountants and journalists are all linked to this network.

It is important for educators to realise that these new systems mean some of the traditional crafts and skills of the work force are about to disappear forever. As a result the training and retraining programs in companies like Fairfax have been extensive. So far there has been a steady process of transition from old trades and skills to those required by the new equipment and methods. People must be capable of being re-educated, if they are to retain jobs or to be trained for new ones, if they are to be employed or to be employable. They must also have *access* to re-training programmes, so that even if the birth rate is declining there is little justification for educational cutbacks. In this context Barry Jones (1982) believes that "the educational revolution ran out of steam some time in the 1970's and there are many who say — in the face of all evidence to the contrary — that we have too many people in higher education. Our problems are likely to be exacerbated by the fact that we have too few."

The social and inter-related educational implications of the computer revolution's impact on information technology demand an active response from all sectors of education, particularly in the use of leisure.

"To say that there will be more leisure is also to state a problem. In the 1950s, people like Dr. David Riesman were ready to welcome the prospect of more leisure because they despaired of the possibility of making work more meaningful. Now, it is almost as common for people to bemoan that nobody knows what to do with leisure. Nobody will pretend that the problem does not exist. In advanced societies, people may be as ill prepared for the benefits of the post-industrial society as are the subsistence farmers of India and Pakistan to face the prospect of a mercantile society. But problems like these are challenges of a kind which it is impossible to shirk. The prospect of more time on people's hands is, of course, a challenge as well as a discouragement. The result could be enlightenment and not the opposite" (Maddox, 1972).

CONCLUDING COMMENTS

Some readers might be disappointed that we have not discussed the educational implications of communications satellites, both active and passive, but the reality is that the critical problems for educators are in the software, not the hardware, in the ends, not the means. As Jones speculates, "there is insufficient data to propose a mathematical formula but it may well be that for every doubling of capacity in communication technology there is a halving of the capacity or the desire of humans to engage in significant communication" (Jones, 1982).

Thus for instance, one might hope that the "global village' influence of IT would be to make us more tolerant. Social scientists, in their studies on the effects of the evolution of the "global village", have observed, however, an inclination for people to select information that presents opinions close to their own and to accept communications which concur with their prejudices. The skills required by school students to strain the surfeit of information, highly selected and dangerously superficial, through the sieve of a well-balanced critical faculty demand a radical reappraisal of educational expectations. The alternative could be massive manipulation by the media managers in a strikingly bipolar society.

Furthermore, as the world economy is being "restructured" it is moving towards an electronic/information based society. The challence to educators is to ensure that students can manage these changes and can fulfill themselves at work and leisure.

We have emphasised that information is power, that one's life chances depend on ability to gain access to and handle information In the world economy the greatest power will be held by those countries where the population has these skills and opportunities. So, in international terms the future of Australia as an independent sovereign state will be fundamentally related to the stock and flow of such skills. The importance of educators, then, is far wider than at first appears, and the importance of their competence with IT is crucial in determining the prospects for Australia.

This problem was highlighted by the 1982 Versailles economic summit of the most industrialised and wealthy countries of the world. President Francois Mitterand of France called for more government control of the development of high technology on a national and international basis. Unmanaged technological development is now being held responsible for the emergence of "technological nationalism" leading to destructive competition, government subsidies, trade barriers, protectionism, and unemployment.

"There is no question that introduction of high technology, including computerisation of the office and factory, is the key to increasing productivity within an industry and even long range economic recovery of the West. On the other hand, while it creates new jobs and even new industries, in many cases these are only a fraction of the jobs eliminated by introduction of more productive systems and automation of the older industries" (Szuprowicz, 1982).

A U.S. study, entitled "Advances in automation prompt concern over increased unemployment", has been presented to the U.S. Congress, and it has clear implications, not only for the American labor market, but also for Australia and other advanced industrialised countries. The study "concludes that automation will cause redundancies not only in jobs that are considered monotonous or dangerous — the traditional areas of factory production targeted for early automation — but also in jobs that require skilled labor. This is because microprocessors can now be fitted into almost any production tool, creating a 'smart' device that can substitute for a human worker in the performance of multiple tasks" (Rothwell, 1982).

The glories of mankind's history have been when destiny has been controlled, rather than the controller. "Those who complain of technology and all its works would be on stronger ground if they were worried instead about the best way of deciding how society should exploit science and technology. Who says what innovations are worthwhile? Some decisions have to be made by individuals in their role as purchasers of

goods. Others are left to manufacturers. Still others, which have a political flavour in the most general sense, must be taken by governments acting on behalf of the communities which they represent" (Maddox, 1972). Educators, too, must respond in their professional capacities as well as in their role of citizens.

REFERENCES

Ausburn, Floyd B. and Ausburn, Lynna J. (1980) Some affirmative views on technology in education. *Unicorn*, 6, pp.25-34.

Bellin, J. (1981) *Rule Britannia*. (London, Jonathan Cape).

Jones, Barry (1982) The limitations of technology. *Communique: the Journal of the New South Wales Institute of Technology*, 3(2), pp. 3-5.

King, F. (1980) Education's steps towards computer assisted learning. *European Journal of Education*, 15, pp.125-137.

Maddox, John (1972) *The Doomsday Syndrome*. (London, Macmillan).

Roemer, Robert E. (1980) Technological studies and the curriculum in higher education. *Curriculum Inquiry*, 10, pp.291-302.

Rothwell, Nicholas (1982) US study fuels the employment debate. *The Australian*, 29 June.

Shannon, A. G. and Ozanne, K. W. (1981) *Research and Development in Computer Aided Instruction: Abstracts and Assessment*. (Sydney, Tertiary Education in Applied Mathematics Project), Report No.26.

Shannon, A. G. and Thornton, B. S. (1982) Some likely effects of computers on the world of education. *Unicorn*, 8, pp.120-130.

Singh, J. G. and Shannon, A. G. (1980) Advanced education and technological change. *Unicorn*, 6, pp.35-43.

Szuprowicz, Bohdan (1982) Computers, productivity and employment. *Pacific Computer Weekly*, 25 June - 1 July, 16.

Thornton, B. S. and Stanley, P. M. (1978) *Computers in Australia: Usage and Effects*. (Sydney, Foundation for Australian Resources).

EUROPEAN JOURNAL OF SCIENCE EDUCATION

Editors:
Karl Frey,
IPN, Kiel, FRG
Richard Kempa,
University of Keele, UK

The *European Journal of Science Education* is an international journal devoted to the publication of articles, reports and information on all aspects and areas of science education. In its coverage of science education research, the journal attaches considerable importance to *applicable* research, i.e. research capable of being applied to educational practice.

European Journal of Science Education is published in collaboration with the Institute for Science Education (IPN), Kiel, FR Germany.

Published quarterly, subscription rates for 1983: £34, $92, DM160.

Personal subscription rates are available, please apply for details.

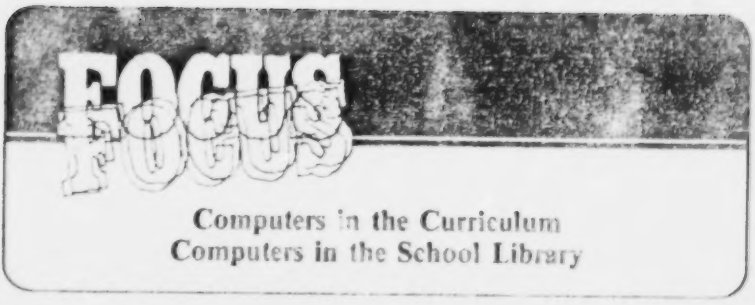
Sample copies are available on request.

Taylor & Francis Ltd
4 John Street, London WC1N 2ET

UNICORN

BULLETIN OF
THE AUSTRALIAN COLLEGE OF EDUCATION

VOL. 10, No. 3 AUGUST 1984



Computers in the Curriculum

A.G. SHANNON*

The integration of computing into the school curriculum is an issue which does not seem to have been successfully addressed so far. By this is not meant an occasional use of simulation or computer-aided instruction, but a consideration of how a subject should be taught and what should be taught in the light of the development of information processing technology. Even mathematics continues to be taught as though the computer had not been invented. Perhaps no changes need to be made, but, if so, this should be a conscious decision based on consideration of adequate information.

Some Basic Issues

We live in an age when information is a commodity, and the relevant aspects of its deployment and processing, as well as its social implications, cannot be neglected by educators. A fundamental question to be addressed is 'with the introduction of new technologies, how can we avoid training simply the elite to cope, leaving the rest overwhelmed by and critical of technological change?' (Jones, 1983). Not only should one deal with knowing how to utilise the technology for data processing, but also with developing the intellectual skills to know how to select information. The processing of data affects all aspects of society. This should be reflected in what is taught, how it is taught, when and to whom. This does not mean a wholesale transformation of the curriculum, but it should result in a gradual transition where appropriate.

Mathematics provides an illustration of what is meant. Before the widespread availability of easy-to-use computing power it would not have been possible within the framework of high school mathematics to deal with such topics as the modelling of crop yield and plant growth, the harvesting of plants and animals, the spread of diseases, the building of tunnels and roads, parking a car, speed-wobble in motorcycles, selling newspapers, housing loan, hire purchase and superannuation repayments, and the mathematical modelling of diseases like diabetes and cancer.

It is now possible to offer students a wide range of interesting and realistic problems which, in fact, require less mathematical knowledge than current

* Tony Shannon is Head of the Mathematics Education Unit, N.S.W. Institute of Technology.

high school courses. The difference is that until now mathematics at both the secondary and the tertiary levels has concentrated on finding explicit closed-form solutions (i.e. a formula involving a combination of algebraic and elementary functions) to a class of fairly well circumscribed problems. Any problem without such a solution was considered to be 'insoluble' and to be avoided, certainly at high school level. This emphasis has inculcated in students an approach to mathematics which leads them to view the subject as the manipulation of symbols and mysterious techniques rather than as an approach for the analysis of complex situations. Problem solving with the computer can become more than the reapplication of rules.

In the past, numerical calculation was a lengthy and tedious task, so that any mathematical problem whose solution could not be expressed in terms of a formula involving simple algebraic formulae or the tabulated elementary functions was the job of the specialist. Even basic computational approaches such as Simpson's rule for numerical integration and Newton's method for solving equations were seen as artificial adjuncts to the overall syllabus.

Now students have access to simple-to-use computing power which until recently was reserved for research mathematicians and engineers. Numerical methods can now be moved closer to the centre stage of high school mathematics.

The computer will make irrelevant much, but not all, of the traditional type of mathematics based on formula solutions. It is not that computing methods will supplant mathematics so much as enrich it by permitting an emphasis on qualitative ideas, shrewd guessing and analytical reasoning.

The purpose of school mathematics can then be the education of students through mathematics rather than the training of them for tertiary courses. (A byproduct might be that those who do go on for further study will be better prepared.)

Interdisciplinary Role

The interdisciplinary type of analysis which has been ushered in by the computer age can also be illustrated by such paradigm examples as a falling raindrop, population growth, and the pendulum. In their simplest form these examples are typical of the well circumscribed kind of problem for which formula solutions exist. However, as soon as any realism is added to these examples, such as friction in the case of a falling raindrop, a restricted growth rate law in the case of population growth, and non-linearity in the case of the pendulum, formula solutions cannot be found, and any approach in such a spirit will not yield useful information (Botten and Chiarella, 1983).

The challenge to mathematical educators of open-ended problems is unpopular, but if the emphasis in mathematics continues to be on shoving symbols around, students will become even more alienated from the subject.

They will be perplexed by the fact that they are doing, albeit in a roundabout fashion, what can be done more efficiently by a computer.

Comments along similar lines can be made about other school subjects and particularly the inter-relation between subjects: computers can be a genuine integrating force in the school curriculum. They are certainly not the special preserve of the mathematicians. Nash's (1983) comment is pertinent: 'nor is it uncommon for a school's computer to be delivered direct to its maths/science department, or to its business studies department, there to be zealously guarded against all uses except the teaching of programming to the brightest kids, or to train the girls in office practices!'

The (at least) occasional integration between subjects offers the opportunity for simulation games with classroom computers. Here educators can respond to, rather than react against, the fascination of video games for children. Simulation can bring an air of reality to many problems. The role playing that they encourage can also develop facets of students' intellectual and emotional development which are not readily measured in formal examinations. As a learning tool simulation offers opportunities for cooperation in genuine group learning situations. The indiscriminate use of simulation is not without dangers and difficulties and teachers would generally require some specific preparation in their use (cf Kohl, 1977).

Conclusion

Elsewhere (Shannon and Hortle, 1983) we have stated the need for a National Co-ordinating Committee on Computers in Schools and of developing effective evaluation procedures.

Lessons from other countries should not be ignored, and by way of conclusion attention is drawn to the assessment by Shears and Dale (1983) that: 'the use of computers in education is not a practice which is accepted or even considered desirable by the authorities in all the countries which were visited . . . In the developed countries, there is a division of opinion on the use of computers which to us in Australia may appear to be surprising'. On the basis of this they make a useful distinction when they divide the countries they studied into 'under-developed and uncertain', 'developed but reluctant', and 'developed and committed'. Included in the 'developed but reluctant' category are Japan, Sweden and Germany.

In Sweden, for instance, computers are generally confined to science and economics in Years 10-12. At this level they offer the possibility of inter-disciplinary approaches to problems, as suggested above. In Japan, children acquire computer literacy in their normal living, and there is little regard for computer aided instruction in the highly motivated and intensely competitive Japanese classroom. In Germany, according to Shears and Dale, 'traditional attitudes to teaching and syllabuses . . . are not seen as compatible with the large scale introduction of computers into the learning environment'. It must be emphasised that in none of these countries is the availability of resources for the purchase of hardware or the provision of software seen as the problem!

Note

These are extracts from some comments on *Teaching, Learning and Computers: report of the National Advisory Committee on Computers in Schools,* 17 October 1983, which were prepared by the author at the invitation of the Council of The Australian College of Education. They were submitted by the Council to the Commonwealth Schools Commission in the interests of contributing to the debate on proposals by the Commission for a national 'computers in schools' program. Comments on an earlier Commission proposal (February 1983) were forwarded in April 1983 and subsequently were published by the College as *Occasional Paper No. 4.*

References

Botton, L.C. and Chiarella, C. *Computing and High School Mathematics I: Solution of Non-Linear Equations,* Tertiary Education in Applied Mathematics Project, Report No. 32, Sydney, 1983.

Jones, Hywel Ceri. 'Education in the European Community', *Education Today: Journal of the College of Preceptors,* 33(1), 1983, 39-52.

Kohl, H.R. *Writing, Mathematics and Games in the Open Classroom,* Methuen, London, 1977.

Nash, Kate. 'Divisions Reinforced', *The Australian Teacher,* 1983, 23.

Shannon, A.G. and Hortle, B.A. 'Computers in Schools: Comments on Proposals for a National Programme', *Australian College of Education, Occasional Paper No. 4,* 1983.

Shears, L.W. and Dale, E.C. *Computers in Education,* Office of the Co-ordinator General of Education, Melbourne, 1983.

New Education, Volume 7, Numbers 1 & 2 (double issue), 1985

INTELLIGENT COMPUTER-AIDED INSTRUCTION

A. G. SHANNON

New South Wales Institute of Technology

ABSTRACT

A mechanistic view of man and an anthropomorphic view of computers is leading to confusion about the scope and limitations of computers in education. What *Time* (February 20, 1984) said of the university applies to all sectors of education: "the university will have to decide one of the definitive issues of the times: how best to utilize the computer in its curriculum". This paper discusses some controversial issues of artificial intelligence as signs of confusion about computers and yet which have consequences for the intelligent use of computers in education. It is alleged that there is a philosophical basis for the confusion.

Introduction

"Towards the Thinking Computers" was the catchy title of a 1984 focus on computers in *The Australian*. The previous year *The Sydney Morning Herald* had serialized "The Super-Intelligent Machine" by Adrian Berry. That these are sensitive topics was seen by the spate of letters they provoked. At first sight issues are sensitive because it seems that machines are becoming as intelligent as man. The problem really, however, is that we have tended for too long to view man as a machine. As Weizenbaum (1976, p. x) points out: "there is a difference between man and machine, and, ... there are certain tasks which computers *ought* not to be made to do, independent of whether computers *can* be made to do them".

The confusion, however, is widespread. A recent popular computer magazine told its readers that thinking computers will probably be within the lifetimes of people living today, and that computers that can think will be computers with emotions! At a more professional level, such eminent artificial intelligence researchers as Herbert Simon and Allen Newell (1958) have claimed that "there are now in the world machines that think, that learn, that create".

There is also a question of language since many terms are used in different senses. Fundamentally, though, the issue is philosophical: "the artificial intelligence debate, taken to extremes, is a matter of philosophy" (Hansen, 1982, p. 323).

Just because a machine can imitate many logical operations of the brain, does this mean that it can think? Just because we cannot think without a brain, does this mean that the brain is the organ of intellect as the eye is the organ of sight? "A microanalysis of brain functions is, moreover, no more useful for understanding anything about thinking than a corresponding analysis of the pulses flowing through a computer would be for understanding what program the computer is running" (Weizenbaum, 1976, p. 136).

Human knowledge

The philosophies which have most influenced educators in the English speaking world have been Kant's doctrine (from which Deweyism is derived) and, Empiricism, and, more recently, Marxism. Kant claimed that knowledge was relative to the structure of the mind, not reality. The Empiricists say that the intellect merely classifies what the senses know. For Marxists the

013416

human and other animals differ only in degree, and hence totalitarian authority makes sense however it is disguised.

An approach to the basic distinctions can be made by means of an example. When I know the clock on the wall, there is a clock on the wall and a clock in my mind. There is a "two-ness" of *existence* but not a two-ness" of *thing existing*. The clock I know in my mind is obviously not a material clock: still less is my knowledge of "what a clock is", (the nature of clock), material. The universal "clock" has no material existence at all. This is why empiricists cannot explain the root of knowledge. They reduce intellect to a sense. A sense knows singulars only; I cannot see "clock" but I can see "this clock". The intellect, on the other hand, knows universals, and can only know the singular after first knowing the universal. I can recognize that this object is a clock only after I know what a clock is. This is in sharp contrast with the position of the empiricists who say that the intellect merely classifies what the senses know and cannot know anything beyond what the senses know. The intellect understands the *universal* first, just as sight sees *colour* first, but I can understand the concept of horse only after I know a horse: we know the thing first, not the concept.

The distinction between a concept and an image is that the former is in the intellect whereas the latter is in the sense. For instance, I can draw triangle imagined, but I cannot draw triangle conceived. An image must be caused by that of which it is the image, but a concept is a sign, and a sign is something which makes known something beyond itself. A sign can be formal or instrumental. Smoke is an example of an instrumental sign. My mind uses the smoke to get to know the fire. All material signs are instrumental — they are things first and only signs consequently. They give mediate knowledge. But concepts are formal signs which do not exist in the physical world although some concepts are imposed on our mind by the nature of reality. Concepts give immediate knowledge.

Artificial intelligence

Having said all that it cannot be denied that there is a branch of computer science which is known as artificial intelligence. This is concerned with the information processing functions of the *brain*: receipt, recall, operation, output of data.

Such functions of the *intellect* as abstraction and induction are beyond the scope of the machine. To see this we need to consider the two basic operations of the human intellect. The first is the understanding or the apprehension of intelligible objects, by which we know more or less distinctly what things are. The second operation is judgement, by which we compose or divide what we have grasped in simple apprehension.

In induction the intellect sorts out from sense experience what is only incidental and grasps what is essential. Induction is thus very like abstraction, the distinction being that induction is directed towards judgement and abstraction towards concept. For example, the intellect induces that "every animal has sensitivity" from direct observation of particular cases of sensitive animals, whereas the intellect abstracts the concept of animal from all particular and contingent animals.

Apprehension is directed towards essence, whereas judgement is directed towards existence. Thus, if we understand what grass and green are, we can write them in affirming "grass is green", by which we understand how grass exists, namely as green. Or, having grasped what man is, we divide man and grass by denying "man is not grass", by which judgement we understand how man does not exist, namely as grass.

We can distinguish or abstract through both these operations of the intellect, and the laws of abstraction differ in the two cases. Thus, in abstraction through simple apprehension we can abstract what is not separate in reality, but the intellect cannot abstract or separate in judgement what is united in reality. For instance, one can consider human nature without considering the

various individual men in whom that nature exists, but if we judge "this man is not white" when in reality he exists as white, then our judgement is false.

The problem is compounded by three things: the failure to make these distinctions between the intellect and the brain, the equivocal use of such terms as intelligence and thinking, and the fact that computers can do very easily some tasks which would be exceedingly difficult for a human.

Yet there are some tasks, such as learning to speak, which are beyond the scope of the computer. Here some will take issue: by human speech is meant something much more complex and much richer than pre-programmed responses to cue words. Missed predictions in the past have not acted as deterrents for extravagant claims for the future. Thus, Robert Jastrow, Director of NASA's Goddard Institute for Space Studies, in enthusing about computing power in the 1990s, says the "reasoning power built out of silicon will begin to match that of the human brain ... What happens after that? Dartmouth President John Kemeny, a pioneer in computer usage, sees the ultimate relation between man and computer as symbiotic union to two living species" (Jastrow, 1978). Hansen's (1982, p. xii) reference in another context is applicable to the computer. "the technology that makes it possible was created by the electronics industry. And the software that makes it all go is the human mind". The same author also makes a telling comment when later he says: "the ability of computers to play winning chess or backgammon, however, may reveal more about the nature of chess and backgammon than it does about the intelligence of computers. That they can calculate is no secret" (Hansen, 1982, p. 311).

None of this should be seen as an attempt to deny the very real achievements of artificial intelligence workers. Such developments as "programmerless programming" and the applications of "expert systems" are indeed exciting. Nevertheless, the limitations, as well as the scope, of computers need to be appreciated by educators if they are to be integrated into the curriculum rather than mere curious appendages to it.

Of course it might well be (though it is unlikely) that Australian educators will follow their colleagues in such countries as Japan, Germany and Sweden and be reluctant to be overwhelmed by computers. Whatever happens, it should be based on informed decisions rather than ignorant default. (cf Shears and Dale, 1983).

Computers in education

Fortunately there is developing a utilization of the approaches of artificial intelligence in what is called intelligent computer aided instruction (Venezky, 1983), p. 40). (Venezky is at the University of Delaware, which is famous for its computer aided instruction, and PLATO, an example of this which is also available outside U.S.A. is described later.)

"Some observers believe computer illiteracy should be tackled with a massive top-down national computer literacy campaign — an approach that would surely fail. And one that may not even be necessary. Fortunately, computers are being designed to be simple to operate and will eventually be programmed in English. In the meantime, children are growing up interacting with computers, playing with computers without even realizing it. Furthermore, the computer is slowly finding its way into the public school system. Although the cost is prohibitive for most school districts, computer use in schools is on the upswing for a variety of reasons.

First, computers offer a cost-effective albeit capital-intensive way of individualizing education. Second, computers simplify the extensive record-keeping required for individualized instruction. Third, familiarity with computers is now considered a strong vocational advantage, a saleable skill" (Naisbitt, 1982, p. 33).

It is in the area of computer based or assisted instruction and learning that the potential of the computer seems not yet to be realized. Much of what passes for computer assisted instruction is little more than electronic page turning and rightly invites cynicism from all but the most dedicated computer devotee (Shannon and Ozanne, 1982).

This is hardly surprising because there is about 100 hours of preparation and programming that goes into the production of about 1 hour of computer based instruction. An analysis and a sharing of the successful efforts in this area are needed to provide guidelines in the modification of existing material and the development of appropriate new material (Shannon and Hortle, 1983). This is not just a naive borrowing from other countries but a realistic alternative to reinventing the wheel

One example will illustrate what can be done: the PLATO system as it operates from the University of Delaware. Not that one could not take examples from closer to home, but the Delaware Office of Computer Based Instruction under the direction of Professor Fred Hofstetter and more than fifty full time staff provide a model. Most of Delaware's teaching departments utilize computer assisted learning and this includes the humanities and fine arts as well as the sciences. The University itself is to be commended in that it pays more than lipservice to the importance of teaching. As some of the services provided by Hofstetter's group are also for elementary and high schools, the PLATO system is of interest to all educators.

There is a network of PLATO users who are continually adding to the system, and there is a PLATO User's Special Interest Group in ADCIS, the Association for the Development of Computer-based Instructional Systems. PLATO courseware can now be used on computers other than Control Data.

The PLATO system

The PLATO system evolved in the sixties under the direction of Dr. Donald L. Bitzer. In the seventies it became a product of Control Data Corporation. A library of more than 6000 hours of instructional lessons in 150 areas is available.

The PLATO system is flexible enough to allow for misspellings and different wordings. With touch sensitive screens it can reduce the intrusion of extraneous skills. Accessories can be added to any PLATO terminal so that students can talk through an audio unit or play melodies through a music synthesizer.

For example, in a lesson to teach melodic patterns, the computer plays a melody and asks the students which notes were played. The students then touch the piano keys on the screen to indicate which notes they heard.

A reading lesson for primary school children includes a list of words on one side of the screen. By touching the appropriate words the students can compose a sentence on another part of the screen, under which appears an animated version of their sentence. There are also lessons for the gifted and talented and for remediation. The latter also include packages suitable for adults who are weak in basic skills.

Another programme might be for medical students and contain a picture of a road accident victim on the video display unit. By touching the "body" with a stethoscope the doctor can monitor various strategies for the victim. As in other PLATO lessons the student's effort is evaluated, and in this case told how quickly the victim died because of the treatment!

PLATO lessons are programmed with a language which was specially developed for computer-based education rather than with a general purpose language. Teachers with no programming experience can author their own lessons or modify existing ones. Hofstetter (1983) lists over thirty different university departments which use PLATO in some part of their curriculum.

Conclusion

If the potential of the computer is to be realized in education, then curriculum development experts need to be aware of research in artificial intelligence and its implications for human learning (with or without the aid of the computer). "It is important, for theoretical reasons, to consider cognitive consequences for students who receive CAI or instruction in programming.

If computer literacy is taken to mean successful involvement in CAI, the intended consequences may be no different from those for a comparable curriculum taught without a computer. In the coming years, however, there is likely to be an increase in what some have called intelligent CAI (ICAI). . . . What distinguishes ICAI from CAI, primarily, is that ICAI aims beyond the ordinary goals of giving information, presenting tests, and keeping records; it also constructs a model of what the student knows. In so doing, it is better able to tailor instruction to correct specific deficiencies and can better advise the teacher about what the student knows or does not know. A program offering ICAI can, in theory, be cognitively more sophisticated than most text-based curricula. Such a program's capability for cognitive diagnosis is thus an important evaluative criterion for both the programmer who creates it and the educator who adopts it" (Amarel, 1983, p. 17).

As background reading to the issues raised in this paper, the interested reader is referred to Frates and Modrup (1983). They aim to survey computer applications in a variety of backgrounds, including education and artificial intelligence. They also forecast major trends in these applications over the remainder of the decade. The research in recent years of the Nobel Laureate, Herbert Simon, is also a useful reminder of the promising links between developments in artificial intelligence and human information processing, particularly the search for meaning that humans put into pattern recognition and problem solving (Simon, 1979, p. 363).

REFERENCES

AMAREL, Marianne (1983) The classroom: an instructional setting for teachers, students, and the computer, in Alex Cherry Wilkinson (ed.), *Classroom Computers and Cognitive Science*, (New York, Academic Press), pp. 15-29.

FRATES, Jeffrey and MOLDRUP, William (1983) *Computers and Life: An Integrative Approach*. (Englewood Cliffs, Prentice-Hall).

HANSEN, Dirk (1982) *The New Alchemists: Silicon Valley and the Microelectronics Revolution* (Boston, Little Brown).

HOFSTETTER, Fred T. (1983) *The Eighth Summative Report of the Office of Computer-Based Instruction*, University of Delaware.

JASTROW, Robert (1978) Towards an intelligence beyond man's: *Time*, 20 February, p. 59.

NAISBITT, John (1982) *Megatrends: Ten New Directions Transforming Our Lives* (London, Macdonald).

SHANNON, A. G., and OZANNE, K. W. (1982) *Research and Development in Computer Aided Instruction. Abstracts and Assessment*, Tertiary Education in Applied Mathematics Project, Report No. 26.

SHANNON, A. G., and HORTLE, B. A., (1983) *Computers in Schools*, Australian College of Education Occasional Paper No. 4.

SHEARS, L. W., and DALE, E. C. (1983) *Computers in Education*. (Melbourne, Office of the Co-ordinator General of Education).

SIMON, Herbert A. (1979), Information processing models of cognition, *Annual Review of Psychology*, Vol. 30, (Palo Alto, Annual Reviews).

SIMON, Herbert A., and NEWELL, Allen (1958), Heuristic problem solving: the next advance in operations research, *Operations Research*, 6, p. 8.

VENEZKY, Richard L. (1983) Evaluating computer aided instruction on its own terms, in Alex Cherry Wilkinson, *Classroom Computers and Cognitive Science*, (New York, Academic Press), pp. 31-49.

WEIZENBAUM, Joseph (1976) *Computer Power and Human Reason: From Judgement to Calculation*, (San Francisco, W. H. Freeman).

JOURNAL OF

TECHNICAL AND VOCATIONAL EDUCATION

ISSUE - 3

1986

TECHNICAL TEACHERS TRAINING INSTITUTE

MADRAS

20

Computer Technology and the Curriculum: Some Questions

SHANNON A.G.

ABSTRACT

The rapid inclusion of computer technology within the world of education is seen by some as an unwarranted intrusion and by others as inevitable progress. Progress presupposes a desired direction; this paper questions some of the assumptions underlying the educational use of computers and their possible effects on the curriculum.

Introduction

To discuss various issues which pertain to the curriculum and computers, several distinctions need to be made at the outset. In any consideration of the curriculum one must clearly distinguish means and ends, and this imperative is very urgent when the role of computer technology is under consideration because of the momentum of the computers in schools movement.

We must distinguish why we want computer technology from what computer technology (hardware and software) is available. To do this we need to distinguish amongst teaching or learning

- about computers
- computing
- by computers
- through computers
- with computers

Each facet raises different questions for the curriculum, and we shall discuss aspects of each.

A number of issues are raised here in a preliminary manner. To assess and evaluate would require more evidence than is currently available in reasonably objective or replicable form. It is hoped though that an awareness of the questions outlined here will help to channel the energy and resources currently being expanded on computer technology into directions where the various goals (when they have been articulated) are compatible within the framework of the total curriculum.

Curriculum Issues

Teaching about Computers

Learning and teaching about computers can include a spectrum of courses ranging from information technology and computer science through programming languages to courses on computer literacy and computer awareness.

To start with the last types of courses, several questions suggest themselves: What is really being attempted? What are the criteria for achieving it? To what extent are schools in richer areas better able to implement programs?

Shannon and Hortle (1983) suggest that "some criteria for computer literacy include (*a*) being at ease in computing situations in everyday life, (*b*) being aware of the social changes caused by computing technology, (*c*) having a working competence with computing skills related to the foreseeable needs of the ordinary citizen and (*d*) having a basic understanding of

013416

the scope and limitations of computers. . . this literacy must be viewed in the context of the total curriculum". The general educational level of the community is at issue here as we move to an era of information technology. The wider curriculum is involved as educators must be concerned not only with access to data but also with the critical utilization of information.

At the Third International Symposium on World Trends in Science and Technology Education in Brisbane in December 1984, there were many papers about courses on "Science, Technology and Society". Such courses, if computer literacy and historical perspectives are involved, can be another source of integrating the curriculum. Students whose career goals might be narrow can contribute to such courses: the history student, the technical student, the science student, the mathematics student, the computer buff, and so on, all have points of view and skills to put into such courses. A big difficulty is that they require an organisation of the school day other than the factory method, and realistically that is not always easy. Trial courses on a semester basis are feasible — long enough to make some real headway but not impossibly long to organise. Such courses though need teachers who can act as coaches, are able to utilise the students' knowledge acquired elsewhere, to guide, co-ordinate and collate rather than to be the dispenser of knowledge. This has implications for the selection, education and development of teachers.

Teaching Computing

The integration of computers into the curriculum offers the possibility — not the certainty — of enriching it, without stretching it. The addition of new courses such as computer programming is another issue unless like Logo, or Prolog or even APL, they are part of a wider educational environment.

One suspects at times that a principal reason for teaching programming is that it is easier than integrating the computer into the curriculum. If not, what is the role of programming as a subject? Is mastering a computer language equated with programming?

What are the criteria for choice of a language? The popularity of BASIC looks suspiciously like convenience. BASIC has some advantages; it also has many disadvantages. The point at issue though is: should we choose a programming language because the machines are available with it and a few teachers know a version or two of it? Should we not ask ourselves: what are the benefits of programming for students? to learn to think more logically? to become better problem solvers? to improve proficiency in subjects with quantitative components? to learn hypothesis testing? What evidence is there of the benefits of computer programming at school level?

For instance if one is concerned with the importance of nomenclature, notation and language as tools of thought one might argue for APL as an educational programming language: after all, it is primarily a notation which can be implemented on a computer (Iverson, 1980). It is a high-level language, easy to learn, (unless one has first learned BASIC!) and it is easy to debug. The only real problems are some of the difficulties that its character set causes in graphics/printer interfaces. Not that I am arguing the case for APL or against BASIC: I am pleading that we put the horse before the cart and work out what languages if any, should be taught at different stages of the school curriculum on educational grounds, not for the sake of the computing industry.

> "The great diversity of programming languages makes it impossible to rank them on any single scale. There is no best programming language any more than there is a best natural language. "I speak Spanish to God, Italian to women, French to men and German to my horse," said Charles V (presumably in French). A programming

language too must be chosen according to the purpose intended." (Tesler, 1984).

The inclusion of computing studies, or even computing science, as a separate subject involves the answering of analogous questions. The least convincing answer educationally is job-preparation; not that one should go to the other extreme and avoid any taint of vocational foundations, but predicting detailed trends in the computer industry is notoriously difficult because of rapid development in implementation of its technology.

Teaching by Computers

Learning and teaching by computers includes those programming languages which are used as part of the learning process in other subjects rather than in their own right, and it includes computer-based learning.

Here too, one must ask: what are the criteria for selecting software, given that the hardware is often purchased before defining the educational goals and values that the computer is supposed to serve?

Computer Assisted Instruction, CAI, has many implications for the curriculum. In passing it should be noted that CAI tends to be the U.S. terminology whereas Computer Assisted Learning, CAL is preferred in the U.K. CML, Computer Managed Learning, differs from CAI in that it is more concerned with testing student performance, advising students on their routes through structured courses, reporting on performance and progress, and quality of tests. The differences between CML and CAI will probably disappear in time.

Leiblum (1977) provides a useful discussion of the rationale for using CAI. Broadly speaking the effective use of CAI requires a clear delineation of its strengths and weaknesses and the purpose to which it will be put. The latter might be to reduce the amount of time for staff/student contact, to provide basic remedial instruction of a tutorial type for students of varying entry level, to supplement or to replace traditional instruction.

Hooper (1977) compares CAI and CML (the poor man's CAI!) in an article reproduced from the Bulletin of the Centre Imago of the Catholic University of Louvain, a cooperative development on media-based educational systems in higher education. According to Hooper, the major problem with CML is the large amount of the curriculum development and media production that a sophisticated individualised learning system involving the computer requires, although ICL's CAMOL, Computer Assisted Management Of Learning, has kept costs low by running in batch as opposed to interactive mode.

Hooper's distinction between CAI and CAL is interesting. He sees the former in the tradition of programmed learning and teaching machines, whereas the latter uses the computer as a learning resource in simulation and modelling situations. While not denying the importance of these latter modes, the distinction can be blurred because even a programmed learning approach to CAI can, with a bit of effort, take advantage of the sorting and randomising capabilities of the computer.

Hooper (1976) distinguishes two dominant traditions in CAI — the computer as a tutor and the computer as laboratory (simulation, problem solving, calculation, data bases). The latter derives from the changing nature of certain academic disciplines as a result of the impact of computer technology. Of course, there are combinations of the two roles in various institutions.

Hooper favours the computer as laboratory because of its superiority in bringing home to the student the effects of altering the parameters of a problem and because it cannot compete with the

superiority of a human teacher as an extremely sensitive, adaptive control system.

The objectives of much CAI are content-oriented and not educational process-oriented. As well as a model of computation, there needs to be built in some adaptivity to the learner if CAI is to have a useful tutorial role. Hooper sees CAI as a subset of CAL.

A useful review by Harding (1980) of nine major CAI studies in the '70's, while acknowledging the danger of "a technology in search of an application", included among the advantages of current work in CAI, the fact that most of the development has been initiated by teachers rather than educational theorists and that it has forced people who work in education to think more about how we teach. Harding includes a perceptive analysis of transferability. He acknowledges that programs and packages are the prime candidates for transfer, but feels that to give the student more freedom to capitalise on the powers of the computer, less constraint should be imposed by the software. To this end he feels that ultimately it is necessary to expect the student to write at least some of the program. In saying this he is not confusing learning about computers and learning *with* computers, but arguing that the educational documentation, including the problems that the student studies, are of prime interest.

Thus the usual distinction in computers and education is between the teaching of computing and teaching with computing, whereas some advocate the teaching of programming as a means of learning the algorithmic approach to problem solving and developing the student's capability for logical reasoning.

The main questions that must be considered before CAI is introduced are listed by Nievergelt (1980) who also summarises a number of projects in a useful review article to which is appended an annotated bibliography. The author traces the development of CAI from an outgrowth of the programmed instruction movement to the current proliferation of "smart" machines, each containing a microcomputer, keyboard and screen. In between there has been a period when the early optimism was dampened and Nievergelt lists a number of reasons to explain this. Thus the antagonism of the problem-solving exponents towards CAI is explained historically by the author as a reaction against the trivial use of computers as "electronic page turners". He then outlines what one needs to consider before getting started in CAI, and claims that today it makes no sense to start a CAI project unless one is willing to write most of the necessary courseware. The article finishes with considerable discussion of strategic considerations and a manual of style for the design of instructional dialogues.

Perhaps a few words about authoring languages and their role in curriculum development and computers are appropriate at this point. An authoring system is a set of programs which permits the teacher to create a computer-based curriculum or courseware without programming. Kearsley (1982) surveys the development and characteristics of authoring systems in the domain of computer-based education. The authoring system automatically generates the debugged code which corresponds to the specifications of the content to be taught and the instructional strategy to be used. The writer distinguishes instructional languages such as LOGO and SMALL TALK which are primarily designed to facilitate the use of the computer by students as a learning tool, rather than by teachers to develop curriculum. With a few exceptions, such as PILOT, author languages are just as complex as any other programming language. The writer outlines three major types of authoring systems: macro-based, form-driven and prompting, and illustrates each. There is also a comprehensive list of references covering the principal literature on the subject.

Teaching through Computers

Computers can play an integrating role in the curriculum by means of modelling and simulation. To paraphrase Spanier (1981), the characteristics of such programs involve the following requirements:

(*a*) a focus on problem-solving;

(*b*) experience in both oral and written communications;

(*c*) familiarity with cognate disciplines;

(*d*) exposure to paradigms of inductive and deductive reasoning;

(*e*) confidence acquired in open-ended problem situations.

The emphases would vary with the maturity of both the teachers and the learners.

For instance, in mathematics the advent of the computer has changed "the attitudes of mathematicians to the idea of what a solution is. Before the computer came, the ideal was to 'solve' a differential equation in the form of a 'closed' formula involving familiar functions, or infinite series. Now, it is often more informative to have the computer print the solution in graphical form, or to display it visually to be modified by a light-pen, or even to make a film to show how solutions change with time. This change in the form of a solution leads to changes in the questions asked; now one often deals with 'discrete' mathematics rather than the 'continuous' model of classical mathematical physics." (Griffiths and Howson, 1974).

These issues are now generating fierce debate at the undergraduate level about the composition and balance in degree level mathematics [Ralston (1984)]. The arguments at the tertiary level will no doubt eventually spill over into the secondary school: should we wait for this to happen or should we continue to get away from the old top-down approach to curriculum development?

In bringing the computer into the curriculum we have to distinguish between solving an educational problem and merely shifting the problem. In mathematics it is now possible to offer students a wide range of interesting and realistic problems which, in fact, require less mathematical knowledge than current high school courses. The difference is that until now mathematics at both the secondary and the tertiary levels has concentrated on finding explicit closed-form solutions (i.e. a formula involving a combination of algebraic and elementary functions) to a class of fairly well circumscribed problems. Any problem without such a solution was considered to be 'insoluble' and to be avoided, certainly at high school level. This emphasis has inculcated in students an approach to mathematics which leads them to view the subject as the manipulation of symbols and mysterious techniques rather than as an approach to the analysis of complex situations. Problem-solving with the computer can become more than the reapplication of rules. It involves what might be called "qualitative mathematics".

In the past, numerical calculation was a lengthy and tedious task, so that any mathematical problem whose solution could not be expressed in terms of a formula involving simple algebraic formulae or the tabulated elementary functions was the job of the specialist.

Now students have access to simple-to-use computing power which until recently was reserved for research mathematicians and engineers. Numerical methods can now be moved closer to the centre stage of high school mathematics. The computer will make irrelevant much, but not all, of the traditional type of mathematics based on formula solutions. It is not that computing methods will supplant mathematics so much as enrich it by permitting an emphasis on qualitative ideas, shrewd guessing and analytical reasoning. The purpose of school mathematics can then be the education of students through

mathematics rather than the training of them for tertiary courses. (a byproduct might be that those who do go on for further study will be better prepared.)

The challenge to mathematical educators of open-ended problems is unpopular, but if the emphasis in mathematics continues to be on shoving symbols around, students will become even more alienated from the subject. They will be perplexed by the fact that they are doing, albeit in a roundabout fashion, what can be done more efficiently by a computer.

Comments along similar lines can be made about other school subjects and particularly the inter-relation between subjects: computers can be a genuine integrating force in the school curriculum. They are certainly not the special preserve of the mathematicians, not that I apologise for using mathematics as an example. The recent Blackburn Report notes:

> "Mathematics, taken broadly, is a language having relevance comparable with that of literacy. Very few, if any, studies in higher education or other vocational fields can now be taken successfully by those having only basic arithmetical competencies."

> "The relevance of mathematical concepts to all technical and technological studies is obvious, but statistics and a grasp of quantitative reasoning are also required in most areas of the humanities, and in social and behavioural sciences. Those lacking such a base are at a disadvantage in many aspects of living." (Lyons, 1985).

The Blackburn Report recommends that all students in Victoria in Years 11 and 12 study at least one three-unit sequence in each of the arts-humanities, science-technology and mathematics as part of a two-year 14-unit course.

The (at least) occasional integration between subjects offers the opportunity for simulation games with classroom computers. Here educators can respond to, rather than react against, the fascination of video games for children. Simulation can bring an air of reality to many problems. The role playing that they encourage can also develop facets of students' intellectual and emotional development which are not readily measured in formal examinations. As a learning tool, simulation offers opportunities for cooperation in genuine group learning situations. The indiscriminate use of simulation is not without dangers and difficulties and teachers would generally require some specific preparation in their use. (cf Kohl, 1977).

Teaching with Computers

The computer has the capability of storing large amounts of data, about an individual or about a system, which is available for almost instantaneous retrieval. It is this property of the computer — an efficient and effective instrument for identifying, collecting and summarising data — that makes its use possible to assist in the management of the educational process. Apart from the usual tasks such as budgeting and planning and timetabling that a computer can handle, proving a boon to harassed educational administrators, it can aid in counselling and monitoring student progress as well as making education less labour-intensive.

Computer-managed learning and associated computer-information resources, including test item banks, have a role to play in incorporating the computer into the total curriculum. This is the subject of teaching and learning supported by computers. It involves the tricky question of whether to purchase an all-purpose computer or horses for courses? Finance is a major constraint, of course, but much of the firmware for the business and support work of the school may be incompatible with what is most appropriate for the strictly academic goals of the school.

A project for a computer-managed learning system is described by Bladon and Bailey (1981). Student progress is continuously monitored by multiple-choice question tests. These produce reports for each student with scores and advice, and reports for each lecturer with individual and class progress. The details of the system are listed as is a frank appraisal of the project. The mechanics of the system are based on PILOT (Process of Individual Learning by Objective Testing) which was derived by Heriot-Watt University in Scotland from the American Teaching Information Processing System (TIPS).

Dellow and Poole (1984) describe microcomputer applications for the educational administrator in such functions as financial analysis, planning, record keeping and report writing. While written with community colleges in mind, it provides useful ideas for any educational administrator.

Related Issues

Sociological effects

The increasing use of computers in society has profound sociological effects on patterns of employment, and opportunities for leisure as well as modes of education. The social implications of computer technology for the curriculum cannot be ignored. In this context two of the recommendations of Shears and Dale (1983) are pertinent:

> "Each state should establish an Education and Industry body to monitor changes in the workforce due to the increasing use of technology and to support modifications in the educational goals for computers in education to keep abreast of these changes. (12)
>
> Special education should be given a priority in funding because of the unique potential of computer equipment to assist learning for students with mental or physical disabilities (13)."

Teacher Preparation

Pirie (1982) has a number of useful ideas on this topic, and Anderson (1984) summarises the needs in the teacher training area:

> "A continuing issue is the adequate preparation of teachers already in schools to use computers with confidence in their regular teaching. This need is unlikely to diminish in the near future since many teachers, after an initial introduction to the new technology, wish to further their knowledge about computers and their use.
>
> An associated issue is the preservice education of teachers. The United Kingdom experience is that, while nationally funded schemes make some impact as far as increasing awareness of teachers in schools is concerned, preservice education is harder to change and lags behind. The importance of this factor depends on whether teacher employment is in an expanding or declining phase."

Shears and Dale (1983) address this issue too:

> "In tertiary institutions preservice teacher education on the use of computers in education should be based on the needs of schools, and developed after a clear statement of educational goals has been prepared. Generalist trainee teachers should not all be required to learn programming, and the main focus of their computer education should be on the uses and limitations of computers with CAI/CAL and computers in the curriculum.
>
> An investigation should be undertaken of the cost, efficiency and acceptability of the chain reaction model of teacher training. This involves in-depth preparation by tertiary institutions of specialists who in turn prepare schoolbased consultants, who with a tea approach in schools, develop

appropriate computer programmes for students."

Much is being done now in the area of teacher education, but a concern is that these courses maintain a balance amongst basic technical skills, relevant developments in computer technology, and production of teaching materials.

A lot of the last named is being done by teachers and commercial programmers, partly to fill a vacuum, but mainly for a quick profit. Not that there is anything wrong with making money! The extent to which educational needs and priorities, classroom trials, and hidden assumptions are taken into account is often dubious if one judges the finished product. In this respect, some recommendations of the N.A.C.C.S. (1984) are pertinent:

> "Because of the shortage of specialists, software developed in each state should, in the first instance, be done through centrally or regionally established teams of curriculum specialists, programmers and educational technologists. (10)
>
> Computers should be introduced into primary and secondary schools, but on the basis of previously locally determined and understood educational purposes and not because of the availability of local funds or discounted equipment (8).
>
> A National Clearing House for Computer Information should be established to facilitate the interchange of hardware and software information between States and the cooperative development of appropriate high quality software (6).
>
> Cooperative mechanisms should be established at the National and State levels for ongoing evaluation and review of all aspects of the use of computers in educational institutions and programmes of teacher preparation, including an assessment of the development of positive attitudes among teachers. (7)."

One would hope too that purposes and policies for computer technology and the curriculum would loom largely in teacher education so that the excitement of the action does not obscure their reason and role. Amongst recent authors to address the ways computer technology might respond to overall curriculum needs is Pogrow (1983). He also attempts to balance the articulation of curriculum policy with its implications for the classroom professional.

Evaluation

We have been concerned here with some questions for curriculum reform as they affect courses and teacher education, but we have not raised the urgent issue of evaluation, particularly into how work might split up differently and the implications for educational research on the accompanying policy, sociology and psychology issues.

In many ways, Slatyer outlined the salient features for such research when he said:

> "The long-term ability of the Australian community to cope most effectively with change — to use technology to benefit society as a whole — depends crucially on education. . . it means education that enables the community to understand and use technology, to look ahead to possible social changes, to take initiatives which influence our future directions and to develop flexibility and interests that enhance the value of work and leisure. How relevant is our education system to meet these challenging demands?" (Slatyer, 1983).

The questioning of the use of computers in the class room referred to earlier should not be ignored when discussing their place in the curriculum.

REFERENCES

ANDERSON, J. (1984). *Computing in Schools: An Australian Perspective*. Australian Council for Educational Research, Melbourne.

BLADON, P.R. AND BAILEY, R.E. (1981). Monitoring student progress with the aid of a computer, *Bulletin of Educational Research* **21,** 17–26.

DELLOW, D.A. AND POOLE, L.H. (eds.) (1984). *Microcomputer Applications in Administration and Instruction*, Jossey-Bass, London.

GRIFFITHS, H.B. AND HOWSON, A.G. (1974) *Mathematics, Society and Curricula*, Cambridge University Press, Cambridge.

HARDING, R.D. (1980). Computer assisted learning in higher education, *Studies in Higher Education*, **5,** 101–114.

HOOPER, RICHARD. (1976). To CAI or not to CAI? — that is the question. *International Journal of Mathematical Education in Science and Technology* **7,** 461–473.

HOOPER, R. An introduction to the National Development Programme in Computer Assisted Learning, *British Journal of Educational Technology*, **8, 3,** 1977a, 165–175.

IVERSON, K.E. (1980). Notation as a tool of thought, *Communications of the Association for Computing Machinery*, **23,** 444–465.

SHANNON, A.G. AND HORTLE, B.A. (1983). Computers in Schools: Comments on Proposals for a National Programme. *The Australian College of Education Occasional Paper* No. **4,** Carlton.

SHEARS, L.W. AND DALE, E.C. (1983). *Computers in Education*, Office of the Coordinator General of Education, Melbourne.

SLAYTER, R. (1983). *Resources and Responsibilities: Fostering Technological Innovation in Australia*, Presidential Address, ANZAAS Congress.

SPANIER, J. (1981). Solving Equations is Not Solving Problems, in L.A. Steen, *Mathematics Tomorrow*, Springer-Verlag, New York, pp. 21–28.

TESLER, L.G. (1984). Programming Languages, *Scientific American* **251:** 3, 58–66.

KEARSLEY, G. (1982). Authorising Systems in Computer Based Education, *Communications of the Association for Computing Machinery*, **25,** 429–437.

KOHL, H.R. (1977). *Writing Mathematics and Games in the Open Classroom*, Methuen, London.

LEIBLUM, M. (1977). A pragmatic approach to initiating a computer-assisted instruction service and some problems involved, *Programmed Learning and Educational Technology*, **14, 3**, 243–249.

LYONS, J. (1985). Vic. Schools to get Tough on Science, Maths Skills, *The Australian*, 1 May, p. 3.

NATIONAL ADVISORY COMMITTEE ON COMPUTERS IN SCHOOLS, REPORT OF (1984). *Teaching, Learning and Computers*, Commonwealth Schools Commission, Canberra.

NIVERGELT, Jurg. (1980). A pragmatic introduction to courseware design, *Computer*, **13,** 7–21.

PIRIE, I.G. (1982). *The Teaching of Computing in Schools*, Reprint 82-1, Department of Computer Science, University of Wollongong.

POGROW, S. (1983). *Education in the Computer Age: Issues of Policy, Practice and Reform*, SAGE, London.

RALSTON, A. (1984). Will Discrete Mathematics Surpass Calculus in Importance? *College Mathematics Journal*, **15**, pp. 371–373 (and pp. 373–400).